MAP GQ–1625

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC MAP OF THE HORSETOOTH RESERVOIR QUADRANGLE, LARIMER COUNTY, COLORADO

By William A. Braddock, Ronald H. Calvert, Joseph T. O'Connor, and Gordon A. Swann

GEOLOGIC QUADRANGLE MAP
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DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Base from U.S. Geological Survey, 1962
Photorevised 1971. Photoinspected 1976
10,000-foot grid based on Colorado coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks, zone 13, shown in blue

CORRELATION OF MAP UNITS

Qal, Qc	Qtg	QUATERNARY
Kd, Kn	Kns, Kpl, Kaf, Kamp, Ki	Upper Cretaceous, Lower Cretaceous — CRETACEOUS
Jm		JURASSIC
		TRIASSIC
		PERMIAN
		PENNSYLVANIAN
Ygp, Yd, Xtc	Xbc	Intruded about 1,400 Ma; Intruded about 1,680 Ma — Middle Proterozoic
YXr	Xks, Xqs, Xfg, Xam, Xcg	Interlayered, metamorphosed about 1,710 Ma — Early Proterozoic — PROTEROZOIC

DESCRIPTION OF MAP UNITS

[All radiometric ages quoted here have been recalculated using the IUGS decay constants (Steiger and Jäger, 1977)]

Manmade fill (Quaternary)—Earth-fill dams of Horsetooth Reservoir

Alluvium (Quaternary)—Deposits of silt, sand, and gravel

Colluvium (Quaternary)—Poorly sorted deposits of silt to boulders forming hummocky topography. Formed primarily by slumping and mass wasting of slabs of block-glide landslides

Gravel deposits on terraces and pediments (Quaternary)—Reddish-brown or white, poorly sorted, poorly to well-stratified gravel. Clasts are commonly derived from Precambrian rocks, but locally are derived from nearby sedimentary rocks. Most clasts are weathered. May be cemented by calcium carbonate

Pierre Shale (Upper Cretaceous)—Within map area, consists of the three lower members of the formation: Mitten Black Shale Member, Sharon Springs Member, and Gammon Ferruginous Member. These three members are mostly dark-olive-gray shale and sandy shale containing limestone and ironstone concretions. Bentonite beds are common in lower part. Thickness about 1,900 ft (579 m), but top not exposed in quadrangle

Niobrara Formation (Upper Cretaceous)—Individual members shown on map but not in cross sections. Total thickness about 350 ft (107 m). Consists of two members:

Smoky Hill Shale Member—Very fissile calcareous shale; dark gray on fresh surfaces, weathers to light-gray plates. Distinctive yellowish-brown micrite about 15 ft (5 m) thick at top; layers rich in *Pseudoperna congesta* common near middle; lower 50 ft (15 m) less calcareous than rest of member and not fissile. Total thickness about 335 ft (102 m)

Fort Hays Limestone Member—Light-gray, thick-bedded micrite. Abundant *Inoceramus* and *Pseudoperna congesta*. About 15 ft (5 m) thick

Carlile Shale, Greenhorn Limestone, and Graneros Shale (Upper Cretaceous) and Mowry Shale (Lower Cretaceous)—Total thickness about 485 ft (148 m). Units cannot be separately mapped due to poor exposure

Carlile Shale—Olive-gray silty claystone and sandy siltstone. About 75 ft (23 m) thick

Greenhorn Limestone—Interlayered dark-gray limestone and olive-gray calcareous silty claystone and siltstone. About 250 ft (76 m) thick

Graneros Shale—Dark-gray to grayish-black siltstone and claystone. About 150 ft (46 m) thick

Mowry Shale—Siliceous, white-weathering shale. As much as 10 ft (3 m) thick

Dakota Group (Lower Cretaceous)—Subdivisions of the Dakota are those defined by Waagé (1955). Shown as group on cross sections only. Total thickness about 290 ft (88 m)

South Platte Formation—Consists of the following members:

First sandstone member—Gray to tan, well-sorted, fine- to medium-grained sandstone. Basal contact interpreted as an unconformity by Waagé (1955, p. 39). About 25 ft (8 m) thick

Middle shale member and Plainview Sandstone Member, undivided—The middle shale is dark-gray carbonaceous shale, thin bentonite, and thin gray siltstone and sandstone beds. The underlying Plainview is gray to tan, thin-bedded, fine-grained carbonaceous sandstone. Total thickness of combined unit is about 185 ft (56 m)

Lytle Formation—Gray to tan, coarse-grained to conglomeratic sandstone and blocky-weathering, varicolored non-carbonaceous mudstone. About 80 ft (24 m) thick

Morrison Formation (Upper Jurassic)—Green, red, yellow, and white, blocky-weathering claystone and siltstone, and interbedded gray micrite and gray, fine- to medium-grained sandstone. About 320 ft (98 m) thick

Sundance Formation (Upper and Middle Jurassic) and Jelm Formation (Upper Triassic), undivided—Mapped unit consists of the Sundance and Jelm Formations (Pipiringos and O'Sullivan, 1976), which have a combined thickness of 197 ft (60 m) at north edge of quadrangle and 140 ft (43 m) at south edge. In descending order, the Windy Hill Sandstone Member of the Sundance is about 10 ft (3 m) thick at north edge of quadrangle, but wedges out near south edge. It consists of flat-bedded, light-gray, fine-grained sandstone and gray clay shale, and unconformably overlies the Pine Butte Member of the Sundance, which consists of about 11 ft (3.3 m) of massive to flat-bedded, fine-grained, gray to white sandstone. The Pine Butte Member conformably overlies the Canyon Springs Sandstone Member of the Sundance. The Canyon Springs Sandstone Member thins southward across quadrangle from about 40 ft (12 m) to 28 ft (8.5 m) and consists of pink, orange-pink, or reddish-brown, fine- to medium-grained, crossbedded calcareous sandstone. It unconformably overlies the Red Draw Member of the Jelm Formation; this unconformity is marked by presence of conspicuous chert pebbles. The Red Draw Member also thins southward, from 134 ft (41 m) to 104 ft (32 m), and consists of orange-pink or reddish-brown, fine-grained, crossbedded calcareous sandstone

Lykins Formation (Lower Triassic and Upper Permian)—Dominantly red and reddish-brown siltstone and fine-grained sandstone containing several thin carbonate beds. Subdivisions of the Lykins, defined by Brotn (1957), cannot be mapped because of poor exposure. Total thickness of formation is about 600 ft (183 m)

Lyons Sandstone (Lower Permian)—Orange to pink to pinkish-gray, fine- to medium-grained, well-sorted quartz sandstone. Commonly well cemented with quartz cement. Characterized by large-scale dune crossbedding. Varies in thickness from about 50 ft (15 m) in southern part of quadrangle to about 30 ft (9 m) in northern part

Owl Canyon Formation (Lower Permian)—Red siltstone and red, fine-grained, ripple-laminated sandstone. About 200 ft (61 m) thick

Ingleside Formation (Lower Permian)—Reddish-pink, fine-grained quartz sandstone, commonly well cemented with quartz or calcite; thick bedded and crossbedded. About 150–175 ft (46–53 m) thick

Fountain Formation (Lower Permian and Upper and Middle Pennsylvanian)—Reddish-brown to purplish-gray arkosic conglomerate, medium- to coarse-grained feldspathic sandstone, and dark-reddish-brown siltstone and shale. Minor thin limestone. Total thickness is 800–880 ft (224–268 m)

INTRUSIVE IGNEOUS ROCKS (MIDDLE PROTEROZOIC)

Granite porphyry—Light- to medium-gray, very fine grained to medium-grained, porphyritic dikes. The dikes are cut by young discordant pegmatites, and cut older concordant pegmatites. The dikes may be related to emplacement of Silver Plume Granite about 1,400 Ma

Mafic dikes—Black to dark- or light-gray, fine- to medium-grained rocks of basaltic or andesitic composition that form a north- to northwest-trending dike swarm throughout much of the northern Front Range. Plagioclase forms phenocrysts in most dikes. Mineralogy and texture vary both regionally and locally; variations are due to primary magmatic factors such as bulk composition and rate of cooling, and are also due to metamorphism that has affected the dikes to varying degrees.

Because of cross-cutting relations at various places in the northern Front Range, the dike swarm is believed to be intermediate in age between the Silver Plume Granite and the Sherman Granite.

Within this quadrangle, the dikes are primarily fine-grained porphyries having blastophitic texture and are classified as biotite-hornblende diorite, chlorite-hornblende diorite, and chlorite-biotite diorite

INTRUSIVE IGNEOUS ROCKS (MIDDLE AND EARLY PROTEROZOIC)

Pegmatite—Coarse grained to very coarse grained. Both Middle and Early Proterozoic pegmatites occur, but cannot be unequivocally separated by field examination. Discordant pegmatites are probably Middle Proterozoic, and are probably related to emplacement of the Silver Plume Granite. Conformable pegmatite are probably mostly Early Proterozoic and may be related to emplacement of the Boulder Creek Granodiorite, or may be migmatitic

INTRUSIVE IGNEOUS ROCKS (EARLY PROTEROZOIC)

Trondhjemite of Thompson Canyon—Light-gray, varies from fine grained and porphyritic to medium grained and equigranular. The body adjacent to the Fletcher Hill fault is not foliated; the body east of Horsetooth Mountain has gneissic foliation. Composed of sodic plagioclase, quartz, microcline, and biotite

Boulder Creek Granodiorite—Light- to dark-gray, medium-grained granodiorite. The body east of the Milner Mountain fault is massive; other bodies have weak to strong gneissic foliation. Whole-rock Rb-Sr age is 1,700 ± 40 Ma (Peterman and others, 1968)

METASEDIMENTARY AND METAVOLCANIC ROCKS (EARLY PROTEROZOIC)

The schist units (**Xks, Xqs**) are metasedimentary rocks; the amphibolite (Xam) is probably metavolcanic. Protoliths of Xfg and Xcg are uncertain. The schists vary in metamorphic grade and mineralogy as shown by the metamorphic zone boundaries (see explanation of "Boundary of metamorphic zones in pelitic rocks"). Whole-rock Rb-Sr age of time of regional metamorphism is 1,713 ± 30 Ma (Peterman and others, 1968). Age of deposition cannot be much older, because Sm-Nd isotopic analyses are consistent with a model age of 1,800 Ma for the formation of continental crust in Colorado (DePaolo, 1981)

Knotted mica schist—Biotite schist containing clots of metamorphic minerals that produce a lumpy or knotted appearance to exposures. Contains thin beds of granule metaconglomerate and quartzofeldspathic schist

Quartzofeldspathic mica schist—Mica schist and phyllite interbedded with quartzofeldspathic metasandstone. Contains thin beds of granule metaconglomerate and knotted mica schist

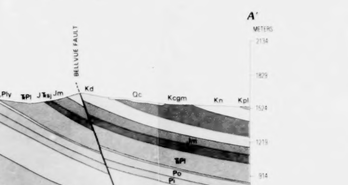
Quartzofeldspathic gneiss—Fine-grained, medium-gray, foliated or strongly lineated rock composed primarily of quartz, plagioclase, microcline, and biotite. Contains dark pods, rods, or lenses rich in hornblende, epidote, and garnet

Amphibolite and hornblende gneiss and schist—Weakly to strongly layered hornblende-plagioclase gneiss or schist locally interlayered with massive amphibolite. Contains thin layers and pods of white to light-green calc-silicate gneiss

Calc-silicate gneiss—Green, brown, white, and red, medium- to coarse-grained rock composed of hornblende, clinopyroxene, epidote, plagioclase, calcite, quartz, and other minerals that are combined in various proportions to form layers and pods

Middle and Early Proterozoic rocks, undivided—Shown on cross sections only

Boundary of metamorphic zones in pelitic rocks—Approximately located, dashed or dotted where projected through non-pelitic rocks, queried where position is uncertain by as much as 2,000 ft (600 m). The boundaries are not located accurately enough to determine their offset across faults. Horizontal lines in the following diagram show major minerals that may be present in each zone in pelitic rocks of units **Xks** and **Xqs**. Dashed terminations of horizontal lines indicate uncertainty of limits. Asterisks (*) indicate minerals that commonly form porphyroblasts in rocks of lower grade than the A boundary; sillimanite also forms knots in rocks of higher grade than the S boundary. In the prograde direction, the metamorphic zone boundaries are as follows: A, first occurrence of andalusite; S, first occurrence of sillimanite; K, last occurrence of andalusite; F, first occurrence of microcline and last occurrence of lepidoblastic muscovite; M, first occurrence of migmatite



Contact—Approximately located. Contacts of Pennsylvanian through Cretaceous formations are solid where exposed, dashed where not exposed

Boundary of block-glide landslide—Dashed where approximately located. Glide mass is stippled

Fault or fracture zone—Showing dip where known. Dashed where approximately located; dotted where concealed. R, apparent upthrown side of reverse fault. M, locality where fault zone contains mylonite

Altered mineralized zone along contact—Contains limonite and clay minerals

Folds—Showing approximate trace of axial surface, and bearing of plunge of hinge lines where known. Dashed where inferred, dotted where concealed. Form of folds, which may change along trace, shown by following symbols

Anticline

Antiform

Syncline

Overturned syncline

Synform

Monocline

Neutral fold—Showing curvature of layers in hinge (a neutral fold has no crest or trough lines); diamond indicates that hinge line is vertical

Strike and dip of beds

Inclined

Overturned

Strike and dip of foliations—May be combined with lineation symbols. Approximate orientations shown by symbol without dip value

Inclined relict bedding—Known to be upright from observed sedimentary structures

Schistosity in metamorphic rocks and metamorphic layering in intrusive igneous rocks

Inclined

Vertical

Folded—Showing map view of fold and dip of long limbs

Crenulations cleavage—Circled number indicates fold episode in which cleavage was formed, if known

Inclined

Vertical

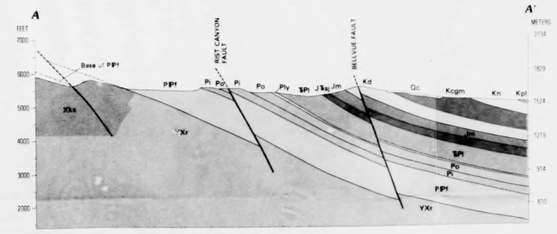
Bearing and plunge of lineations—May be combined with foliation symbols

Multiple symmetric folds

Small folds, crenulations, boudinage, or aligned minerals

Intersection of schistosity and bedding

Intersection of schistosity and crenulations cleavage



GEOLOGIC QUADRANGLE MAP
HORSETOOTH RESERVOIR QUADRANGLE, COLORADO
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3. R. H. Calvert, 1960 (1)
4. J. T. O'Connor, 1959-60 (1)
5. G. A. Swann, 1960-62 (1)

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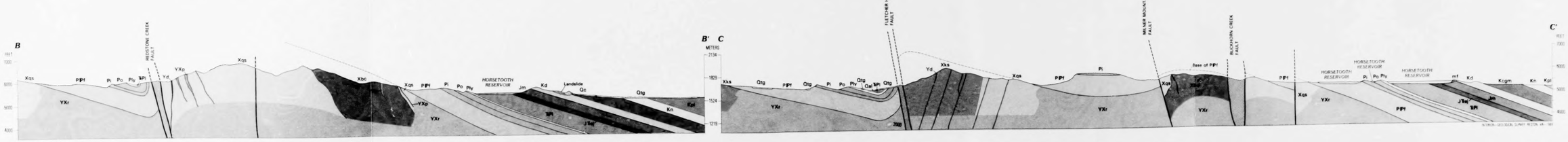

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1989

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GEOLOGIC MAP SYMBOLS

COMMONLY USED ON MAPS OF THE UNITED STATES GEOLOGICAL SURVEY
(Special symbols are shown in explanation)

Contact – Dashed where approximately located; short dashed where inferred; dotted where concealed

Contact – Showing dip; well exposed at triangle

Fault – Dashed where approximately located; short dashed where inferred; dotted where concealed

Fault, showing dip – Ball and bar on downthrown side

Normal fault – Hachured on downthrown side

Fault - Showing relative horizontal movement

Thrust fault – Sawteeth on upper plate

Anticline – Showing direction of plunge; dashed where approximately located; dotted where concealed

Asymmetric anticline – Short arrow indicates steeper limb

Overturned anticline – Showing direction of dip of limbs

Syncline – Showing direction of plunge; dashed where approximately located; dotted where concealed

Asymmetric syncline – Short arrow indicates steeper limb

Overturned syncline – Showing direction of dip of limbs

Monocline – Showing direction of plunge of axis

Minor anticline – Showing plunge of axis

Minor syncline – Showing plunge of axis

Strike and dip of beds – Ball indicates top of beds known from sedimentary structures

Inclined ⊕ Horizontal
Vertical Overturned

Strike and dip of foliation

Inclined Vertical Horizontal

Strike and dip of cleavage

Inclined Vertical Horizontal

Bearing and plunge of lineation

Inclined Vertical Horizontal

Strike and dip of joints

Inclined Vertical Horizontal

Note: planar symbols (strike and dip of beds, foliation or schistosity, and cleavage) may be combined with linear symbols to record data observed at same locality by superimposed symbols at point of observation. Coexisting planar symbols are shown intersecting at point of observation.

Shafts

Vertical Inclined

Adit, tunnel, or slope

Accessible Inaccessible

Prospect

Quarry

Active Abandoned

Gravel pit

Active Abandoned

Oil well

Drilling Shut-in Dry hole abandoned
Gas Show of gas
Oil Show of oil

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